Marshall Avionics System Testbed Facility

Purpose:

To evaluate candidate avionics architecture and components to support the early concept definition, demonstration, and software verification and validation (V&V).

The focus of the Marshall Avionics System Testbed (MAST) is on providing a facility to demonstrate, test, and evaluate advanced earth-to-orbit avionics systems and components such as:

- Avionics architectures and components,
- Guidance, navigation, and control algorithms,
- Health management algorithms
- Software development methodologies.

The primary objective of the MAST is to provide a facility which programs can use to bridge the gap between technology development and technology implementation. The goal is to make this capability available during early program development and also to allow multiple programs to use the lab simultaneously. Some of the benefits the use of the MAST provides a program include the following:

- Early establishment of realistic design requirements and performance specifications,
- Early resolution of technical risk areas,
- Evaluation of competitive designs through test and demonstration in a neutral setting.

The MAST has recently evolved into an integrated set of simulation laboratories. The labs that comprise the MAST are the Vehicle Simulation Laboratory (VSL) , Engine Simulation Laboratory (ESL), and the Actuator Test Lab (ATL). This integrated set of labs provide the capability to integrate, in a closed-loop environment, an end-to-end avionics system required for earth-to-orbit launch vehicles. The capabilities include detailed simulations of launch vehicles, engine systems, environments, and ground systems plus the ability to stimulate various sensors and actuation systems. The labs are designed in modular fashion so that simulations of missing avionics components can be “plugged-in” to the environment. The three labs are interconnected by VMIC fiber-optic VMIVME-5576 Reflective Memory Boards located in each facility. Each

board represents a node on the network and is linked by two fiber-optic cables for passing address, data, and interrupt information. Data written to the on-board RAM of any node will appear or be reflected in the RAM of all other nodes. Running at full speed, the link can support a 6.2 Mbyte/second transfer rate. A redundant transmission mode of operation is supported to ensure that critical data is received error free. The amount of time to transmit data from one node to another can be calculated based on the distance between each node and assuming a typical latency of 1.5 microseconds per node.

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Engine Simulation Laboratory

The Engine Simulation Laboratory (ESL) consists of high fidelity real-time simulations of rocket engine systems with models of high frequency pumps, combustion devices, propellant lines, actuators, valves and sensors. The lab contains both an Electronics Associates, Incorporated (EAI) SimStar and an Applied Dynamics International (ADI) Real-Time Substation (RTS) for the execution of engine models. The SimStar is a hybrid computer that contains both a digital and an analog processor. For execution on the SimStar, a model is partitioned such that the more demanding high frequency portions are executed on the analog processor and the slower portions are executed on the digital processor. The SimStar also includes a real-time display station for the graphical display of simulation data. The ADI RTS is a Power PC based platform used in simulation of real-time models. In addition to its simulation capability, the RTS is equipped with hardware to electrically simulate typical sensor interfaces such as pressure transducers, thermocouples, flow/speed sensors, and RTD sensors.

The lab also includes a load fixture to which engine propellant valve actuators can be mounted. The load fixture is used to simulate the loads an actuator would see while operating propellant valves. The load fixture, which is hydraulically actuated, generates loads based on outputs from valve flow models or commanded static loads.

The Laboratory Command and Data Simulator (LCDS) functions as a simulated vehicle interface to an engine controller through an avionics bus. The LCDS also acts as a node on the reflective memory network for the transfer of simulation data between the Vehicle Simulation Laboratory (VSL) and ESL.

The capabilities of the ESL allow for the development, test, and demonstration of the following:

- Engine avionics systems (e.g. engine controllers, valve actuators, and sensors),
- Engine control and monitoring algorithms,
- Software verification,
- Hardware and software integration.

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Actuator Test Laboratory

The Actuator Test Laboratory (ATL) is operated by the MSFC Propulsion Laboratory and is used in the design, development, and test of actuation systems. The ATL contains several load stands that are suitable for actuators ranging from small solenoids to large thrust vector control actuators. The lab supports active research in the areas of electro-mechanical actuators and power generation and delivery methods. Within the ATL, an interface computer is used to act as the interface between the VSL and ATL. This computer also interfaces with the actuator controller to send actuator position commands and receive position feedback.

Vehicle Simulation Laboratory

The Vehicle Simulation Laboratory (VSL) is designed to provide a tool for the demonstration of advanced vehicle avionics technologies such as the following:

- Flight computers,
- Navigation systems (e.g. Inertial Measuring Units (IMU), GPS receivers, etc.)
- Fault tolerant components and architectures,
- Autonomous Guidance Navigation and Control (GN&C) algorithms,
- Automated software generation and verification and validation products.

The major components of the VSL are:

- Three Encore 91 computers hosting real-time execution of detailed vehicle mathematical models,
- Contraves/Geortz three axis rate table driven by outputs from the vehicle model,
- Display console for real-time display of simulation data and ground station emulation,
- Cabling to support fiber-optic and copper redundant avionics busses,
- Workstations with toolsets (e.g. MATRIXx, Dataviews, G2, TAE+, etc.) to support flight software development, mathematical model development, and data visualization.

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